Working memory impairments after severe Traumatic Brain Injury : what does MEG reveals

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1.ABSTRACT

Many studies of working memory (WM), both in healthy subjects and severe Traumatic Brain Injury (sTBI) patients, with fMRI suggested the involvement of a prefrontal and parietal network activation. To our knowledge, no study of WM after sTBI has been reported with MEG imaging. This technique is however well suited to assess the slowing down of information processing observed in TBI patients. The aim is to assess the spatial and temporal profiles of brain activity during a WM task in sTBI compared to controls. Ten healthy subjects and five sTBI were submitted to a n-back task, with three conditions of increasing WM load. First results are in agreement with cortical networks described in previous fMRI studies. Both patients and controls showed a prefrontal and parietal network activation. The novelty of these results was to reveal that all stages of information processing, involving early visual sensory signals, were slowed down in the patients group. This slowing down increased with later cognitive stages of information processing. Furthermore, patients showed a higher signal intensity than controls. Finally, while controls showed an activation involving mainly the left hemisphere, activation was bilateral in sTBI. MEG appears thus to be an interesting technique for the study of impairments in WM after sTBI. It reveals that these patients showed both a global slowing down of information processing and a higher and more widespread level of activation, presumably as adaptative mechanisms.

2.KEY WORDS

Traumatic Brain Injury, working memory, n-back, MEG imaging.

3.INTRODUCTION

This study aimed to : assess the cerebral correlates of working memory impairments after severe TBI, explore the spatiotemporal brain dynamics using a working memory (WM) task and objectivize which stages of information processing are slowed.

4.METHODS

Five sTBI (mean age 25±3.69, educational level 15±3.20, score=8 on the Glasgow Coma Scale) and ten healthy subjects (mean age 24.5±3.92, educational level 15±3.07) were examined by MEG.

A working memory (WM) task (n-back) was used in this study. A letters sequence were presented on a screen during 500ms, with 3000ms interstimuli time. Subjects were trained before performing the MEG imaging to make sure they understood well each condition of the task. There were three difficulty levels of increasing WM load : 0, 1 and 2-Back (***Figure 1***). In the 0-Back condition, subjects were asked to press a "yes" key (keyboard) for a pre-determined target letter ("S"). In the 1-Back condition, they had to answer "yes" if the current letter was matched to the previous one. And for the 2-Back condition, they had to answer "yes" if the current letter was identical to that appeared 2 back in the sequence.

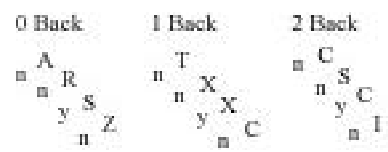

Figure 1 : *illustration of the three difficulty level of the n-back task*

For each participant, Event-Related magnetic Field (ERF) were recorded with a CTF (Vancouver, Canada) whole-head system (151 sensors). A 3D T1 MRI acquisition (Philips, 1.5T) was also performed for surimposition for MEG acquisitions. For each subjects, 6 runs were recorded with 2 conditions (0-1, 1-2, 0-2-Back) in the same run. Presentation order of runs was randomized over all subjects. Performances and Reaction Time (RT) of each subject were recorded. The signals of the brain were filtered with a 0.626-40 Hz bandpass. Eyes movements artefacts and cardiac artefacts were removed. Data were averaged according to each condition. ERF signals were analysed using a classical Minimum Norm Algorythms (MNE ERF) (Brainstrom 2001, *S. Baillet, J.C. Mosher, R.M. Leahy*). Z-scores calculations were performed over each MNE ERF with respect to a baseline-MNE signals (from -450 to -150ms).

5.RESULTS

The priliminary results were in agreement with cortical networks described in previous functional imaging studies. In the 2 groups, sTBI and controls, cortical networks found involved both frontal and parietal cortex. Both control subjects and sTBI showed (1) cortical activations in posterior parietal (BA39/40) and left prefrontal (BA 9/40) areas and (2) an increase of cortical activation intensity with the rise of WM load. However, for sTBI, signal intensity was higher than control subjects for each condition, especially in the prefrontal areas (bilateral). Furthermore, sTBI showed a disrupted activation pattern including supplementary areas (bilateral frontopolar areas, right temporal area).

These results also showed a significant slowing of information processing in sTBI, compared to control subjects. This slowness involved the early visual sensory signal (115 ms for controls, 121.4 ms for sTBI) and increased with later cognitive processes.

6.DISCUSSION

Patients with severe TBI suffered from several cognitive deficits. Deficits in working memory and mental slowness are among the most frequent complaints. The novelty of this study was to assess this slowing down of information processing with MEG. Indeed, our results revealed that slowness involved every stages of information processing, including visual perception stages, but slowness seemed particularly marked for later stages involving the prefrontal cortex.

Cerebral activation in both groups was found in similar regions of the frontal and parietal lobes. However, compared with controls, TBI patients showed a higher and more widespread signal intensity. This could be linked to differences in recruitment of resources or in solving strategy differences between sTBI and controls subjects. It could also be related to a compensation of deficit activation in sTBI, that is, an increase of prefrontal activation could be necessary to maintain performance levels as high as control subjects.

Previous studies in PET and fMRI showed a bilateral frontal and parietal activation. Severe TBI had supplementary areas activated, particularly the temporal areas. This could compensate a deficit in activation of cortical network needed to solve the n-back task by recruiting remote regions. The n-back task performances are known to depend on resources in working memory and temporal areas are known to be involved in long-term memory processes. The limitation of resources in working memory after sTBI could explain the involvement of long-term memory processes to perform the task.

7.ACKNOWLEDGEMENTS

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